ULTRASONIC PROPAGATION WAVE VELOCITY IN MR FLUID AT MAGNETIC FIELD SWEEP RATES

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1. Introduction

MR (Magneto-Rheological) fluid consists of micrometer-scale magnetic particles, surfactant and a carrier fluid such as hydrocarbon oil. MR fluid is a magnetic functional fluid in which magnetic particles gather and form clustering structures when external magnetic field is applied. We need more force to yield the clustering structure, so viscosity and yield stress increases as a whole fluid. By taking advantage of this characteristics, MR fluid is applied to the absorber and dumper. However, the mechanism of formation of the clustering structures is not fully discovered because MR fluid is opaque. Since the ultrasonic propagation velocity is faster when it propagates in the clusters, we can make a quantitative analysis on the clusters in MR fluid by measuring the ultrasonic propagation velocity. In this study, we analyze how the formation of the clustering structures differs depending on sweep rate of the magnetic field. Sweep rate is a parameter which shows how fast we apply external magnetic field on the MR fluid. Bramantya et al. [1] measured ultrasonic propagation velocity for different sweep rates in DC magnetic field. Fujita et al. [2] examined characteristics of MR fluid under the effect of external AC magnetic field. We measured the ultrasonic propagation velocity for different sweep rates in both DC and AC magnetic fields.

2. Experiment

Figure 1 shows the experimental apparatus. The change rate of the ultrasonic propagation velocity $\Delta V/V_0$ is calculated by the following equation.

$$\frac{\Delta V}{V_0} = \frac{V - V_0}{V_0} = \frac{L/T - L/T_0}{L/T_0} = \frac{T_0 - T}{T_0} \tag{1}$$

where V_0 and V are initial ultrasonic propagation velocity without and with magnetic field, respectively. L is the ultrasonic propagation length, and T_0 and T are the ultrasonic propagation time without and with magnetic field, respectively.

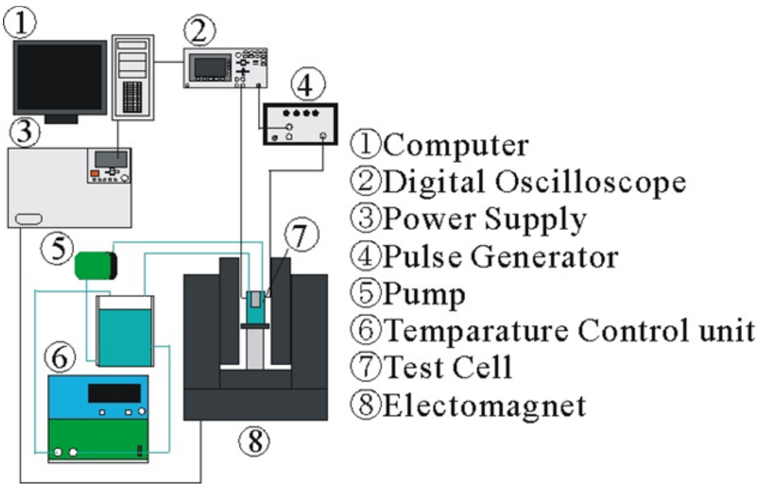

Fig. 1 Experimental apparatus

3. Experimental Results

The change rate of the ultrasonic propagation velocity increases with the magnetic field intensity. Figures 2 and 3 show the time-dependent change rate of the ultrasonic propagation velocity when DC and AC magnetic field intensity increases gradually. B_{dc} is the intensity of the DC magnetic field. B_{ac} and f are the root mean squared value of the AC magnetic field intensity and the frequency of the AC magnetic field, respectively. Increase of the ultrasonic propagation velocity changes is delayed in comparison with the increase of the magnetic field intensity for both DC and AC fields. This delay is connected with cluster formation of magnetic particles.

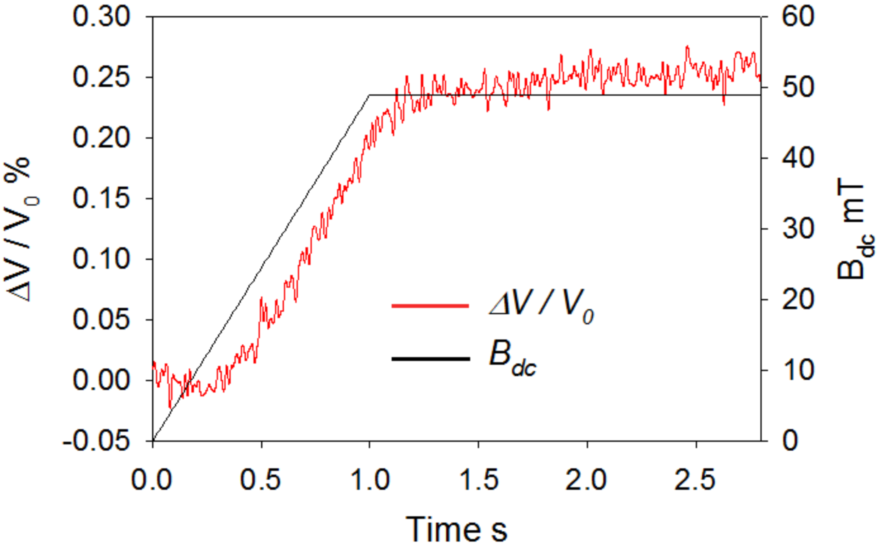

Fig.2. Change rate of the ultrasonic propagation velocity under DC magnetic field

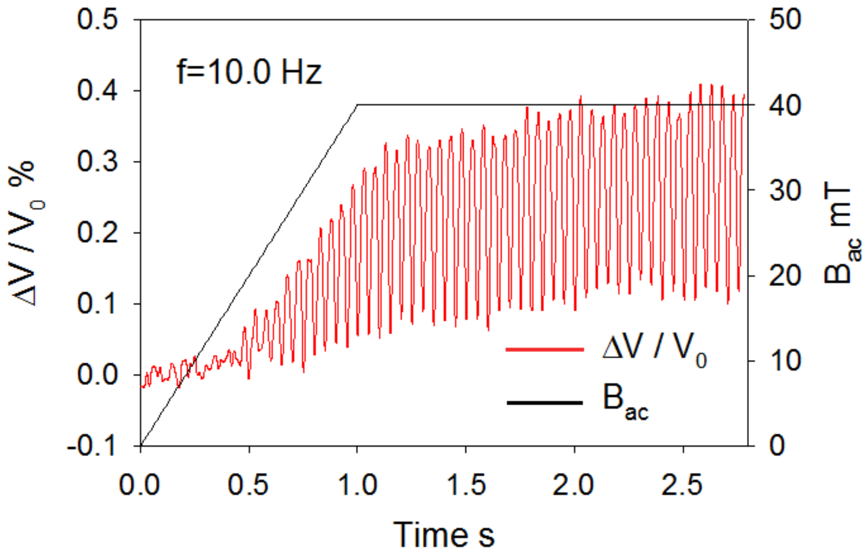

Fig.3. Change rate of the ultrasonic propagation velocity under AC magnetic field

References

[1] Bramantya M.A., et al., "The influence of magnetic field swept rate on the ultrasonic propagation velocity of magnetorheological fluids". Journal of Magnetism and Magnetic Materials, vol. 323 (2011), pp. 1330-1333.

[2] Fujita Y., et al., "Ultrasonic propagation characteristics of a magnetic fluid under AC magnetic fields". International Journal of Applied Electromagnetics and Mechanics, vol. 45 (2014), pp. 667-673.